Marine magnetotellurics imaged no plume beneath the Tristan da Cunha hotspot in the southern Atlantic Ocean

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ABSTRACT

The Tristan da Cunha (TDC) Islands is one of the hotspots in the Atlantic Ocean. The discussion whether its magmatic source is deep in the mantle or in the shallower asthenospheric mantle have not reached consensus yet because of lack of the geophysical observations in the area. The electrical conductivity structure of the upper mantle beneath the area was investigated in this study to provide an answer to this question. Marine magnetotelluric data were collected from 26 sites in 2012–2013. Three-dimensional inversion analysis depicted a high conductive layer at ∼120 km depth but no plume like vertical structure. The conductive layer is mostly flat independently on seafloor age and bulges upward beneath the older lithospheric segment where the TDC Islands are located compared to younger segment south of the TDC Fracture Zone. Bathymetric data on the other hand shows that the northern segment is deeper than prediction for a one-dimensional cooling model suggests. This bathymetric anomaly coincides with a more conductive asthenospheric mantle north of the TDC Fracture Zone. Apparent inconsistency between the absence of vertical structure in this study and geochemical evidences on deep origin materials suggests that either the upwelling is too small and/or weak to be resolved by the current data set or that the upwelling takes place elsewhere outside of the study area. Other observations suggest that 1) the conductivity of the upper mantle can be explained by the fact that the mantle above the high conductivity layer is depleted in volatiles as the result of partial melting beneath the spreading ridge, 2) the potential temperature of the segments north of the TDC Fracture Zone is lower than that of the southern segment at least during the past ∼30 Ma.

Keywords: Marine magnetotellurics, electrical conductivity, upper mantle, hotspot, Tristan da Cunha, Atlantic Ocean

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